was pointed out by Riemann many years ago, and thus the purely idealistic character of theoretical dynamics is again indicated.

The whole of statistical mechanics, which includes the kinetic theory of gases, is a theoretical structure based upon purely mechanical postulates concerning atomic action whereas the quantum hypothesis rules out the purely mechanical conceptions of atomic action and it seems therefore that the quantum hypothesis is likely to lead to profound changes in the atomic method.

As stated above the methods of physics have remained almost wholly unchanged by modern developments, and, although the principle of continuity is in danger of being thrown out by the quantum hypothesis, the other principles of physics seem to be altered by being made more general. (a) The principle of the conservation of energy still stands, but the principle of the conservation of man has become a part of it. (b) The principle of the conservation of momentum retains its validity in a decidedly widened field. (c) The second law of thermodynamics is untouched. Many men who hold a principle narrowly seem to feel that the principle is destroyed by a change which on careful scrutiny turns out to be only a generalization of the principle.

Wm. S. Franklin
Massachusetts Institute of Technology

SPECIAL ARTICLES

HIGH VOLTAGE CATHODE RAYS OUTSIDE THE GENERATING TUBE[1]

Lenard succeeded in getting electrons from a cathode-ray tube out through a thin metal window into the air. The voltage employed was that necessary to produce a 3 cm. spark between small spheres. The window consisted of a piece of aluminum foil 0.00265 mm. thick and 1.7 mm. in diameter.

With a specially designed hot cathode, high vacuum tube, it has been found possible to operate with as much as 200,000 volts and several milliamperes, using a window as large as 8 cm. in diameter. The general design of this tube would seem to permit of the use of still larger windows and higher currents.

The maximum range of the electrons in the air in front of the window has been measured approximately by the luminescence of lime. It is a linear function of the voltage applied to the tube and for an aluminum window 0.0254 mm. thick, is given by the equation:

Range (cm.) $= 0.254 \times$ Kilovolts (max.) $- 17.8$. The lowest peak voltage at which there is appreciable intensity in front of and close to the window is 70 kilovolts, and the maximum range at the highest voltage used, 250 kilovolts, is 46 cm.

[1] Preliminary communication.

The luminosity of the air in the path of the discharge is very beautiful, especially at the higher voltages, where, due to scattering, the beam is seen to spread out and bend around until it finally extends more than half as far back of the window as it does in front of it. The appearance is then that of a solid ball of purple glow with its center a little front of the window.

Calcite crystals, upon being rayed, fluoresce strongly in the orange and remain highly luminous for several hours after raying. In addition to this they may show bright bluish white scintillations. These have been observed while the crystal is undergoing bombardment and for as long as a minute after raying. By slightly scratching the rayed surface of the crystal with any sharp instrument, the scintillations may be produced for as long as an hour after raying.

The area in the neighborhood of a scintillation loses all of its luminosity as the scintillation takes place and then appears dark against the bright orange background.

Under the microscope the spot where the scintillation took place is marked by a little crater with many tiny canals leading into it.

The high voltage electrons from this tube when brought into gases cause various reactions somewhat as Lind finds for radium emanation. The quantity relations are such that large amounts of the resulting substances may be made. For example, with such a tube there has been produced from acetylene relatively large quantities (grams) of a yellow compound which resembles the product previously obtained in small quantities both from the corona discharge in acetylene and from the use of radium emanation.

Many liquids and solids also undergo marked chemical changes under the influence of the high speed electrons. For example, castor oil changes rapidly to a solid material. Crystals of cane sugar turn white in color and, upon subsequent gentle heating, evolve considerable quantities of gas. An aqueous solution of cane sugar becomes acid to litmus upon being rayed.

The effect on organized tissues is very pronounced, as may be seen from the following examples.

When a portion of the leaf of the rubber plant (*Ficus Elastica*) is rayed with 1 milliampere for as long as 20 seconds, the rayed area becomes immediately covered with white latex, as though the cell walls had, in some way, been ruptured. An exposure of as little as 0.1 milliampere for 1 second produces a visible color change with subsequent drying out of the rayed area to a depth corresponding to the penetration of the rays.

The ear of a rabbit was rayed over a circular area 1 cm. in diameter with 0.1 milliampere of current for 0.1 second. Within a few days the rayed skin became deeply pigmented and the hair came out. It was not until seven weeks after the treatment that new hair appeared.

A second similar area was rayed with 1 milliampere of current for 1 second. After several days a scab formed over the rayed area and a few days later the scab came off taking the hair with it. Two weeks later a profuse growth of snow white hair started and soon became much longer than the original gray (drab colored) hair.

A third area on the ear was rayed with 1 milliampere for 50 seconds. In this case a scab developed on both sides of the ear and these scabs later fell out leaving a hole in the ear. The periphery of this hole was at first devoid of hair but is now covered with a growth of snow white hair.

Fruit flies, upon being rayed for a small fraction of a second with 1 milliampere, instantly showed almost complete collapse and in a few hours were dead.

Bacteria have been rayed and an exposure of 1/10 second has been found sufficient to kill even the highly resistant spores of *b. subtilis*.

The phenomena of luminescence, phosphorescence, thermo-luminescence and change of color which take place as a result of electron bombardment from the tube are very striking and easily demonstrated, and many substances which could not be brought into a vacuum can be subjected to electron bombardment in this way.

Detailed reports of this work are now being prepared for publication.

W. D. Coolidge

Research Laboratory, General Electric Company, Schenectady

THE TRANSFER OF TOBACCO AND TOMATO MOSAIC DISEASE BY THE PSEUDOCOCCUS CITRI[1]

Among several thousand tobacco and tomato seedlings in the greenhouse during a year and a half, in no instance was there observed spontaneous mosaic disease. Almost all these plants were repotted during this period, many were cut back and over two hundred were injured and injected with non-mosaic materials. These observations support the opinion of Allard and others that mosaic disease in these species does not arise spontaneously in healthy growths. They are not, however, in agreement with the belief of Woods and of Heintzel that the active agent is an enzyme present in all healthy tobacco plants, or of Hunger and of Sturgis, among others, that mosaic is a physiological disease which arises as a result of unfavorable conditions. In addition, three hundred plants, grown from seeds obtained from a tobacco growth that had had this affection for at least six months, remained healthy; thus we have demonstrated, as others have done previously (Allard, Gardner and Kendrick), that the disease is not seed-borne.

Recently—in June, 1925—an infestation occurred in the greenhouse with the *Pseudococcus citri* (family *Coccidae*; sub-family *Dactylopinae*). These "mealy" bugs were found not only on the normal, but also on the mosaic plants, all having been kept under the same roof. About one month after the insects appeared, twenty of fifty tobacco plants, uninoculated or uninjured, but infested with the bugs, showed typical mosaic disease. Twenty-four normal tomato plants, similarly infested, were removed from the greenhouse and replanted in a field. After a month all developed into typical mosaic growths. On the other hand, thirty-six tomato plants free from *Pseudococcus citri* remained normal after transfer to the field. Insecticides were applied and the greenhouse was freed from these insects. At least five hundred tobacco and tomato plants, forty of which were injured by thoroughly scratching two leaves of each, were subsequently grown there. All these remained healthy. Finally, the pseudococci were removed from mosaic tissues on which they had been feeding and three to five were gently transferred to each of nine tomato and five tobacco plants. Of the former, seven, and of the latter, three exhibited typical mosaic disease after incubation periods of from ten to twenty-one days.[2]

It appears, therefore, that the *Pseudococcus citri* is a vector of the mosaic virus.

To summarize, it may be stated that spontaneous mosaic does not occur in healthy or injured tobacco or tomato, or in these plants injected with non-mosaic materials; nor is the disease seed-borne. If the affection occurs under these conditions, care should be taken to eliminate as a factor the *Pseudococcus citri*, which is a carrier of the mosaic virus in greenhouses, in the same way as are the *Aphididae* in the field.

Peter K. Olitsky

The Rockefeller Institute for Medical Research

[1] I am indebted to Mr. Peter P. Haselbauer for his technical assistance and for his hearty cooperation.

[2] The incubation period, after injection of mosaic virus, is generally about ten days. Concentration of the virus, however, to one tenth of its original volume shortens this period to five days.